ASTRONAUTICS

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New Model Stability Tests

Report on September 10 Dry-Fuel Flight Tests At Mountainville, N. J.

The second series of stability tests using light-weight, powder driven models was successfully completed by the Experimental Committee at Mountainville, N. J. on September 10, 1939.

A cleared portion of a farm owned by Charles Westendarp was kindly placed at our disposal through the good offices of Alfred Best, a member of the Society. Taking part in the tests were a number of members and spectators, including John Shesta, Chairman of the Experimental Committee, L. Goodman, R. Healy, B. Hecht, G. E. Pendray and Mrs. Pendray, F. H. Pierce, and the writer.

W. Eugene Smith from Black Star
A Model Rocket Zooms Skyward

Purpose of the Tests

Using the first data obtained from the 1937 Pawling model tests as a starting point, three members of the Committee constructed light cardboard and balsa wood models into which the "cartridge" part of the ordinary commercial sky-rocket could be slipped to provide the propulsion or lift required for the test. Mr. Pierce, who together with Mr. Shesta built the launching rack

(Cont. on P. 3)

THE AMERICAN ROCKET SOCIETY was founded to aid in the scientific and engineering development of jet propulsion and its application to communication and transportation. Three types of membership are offered: **Active,** for experimenters and others with suitable training; **Associate,** for those wishing to aid in research and publication of results, and **Junior,** for High School students and others under 18. For information regarding membership, write to the Secretary, American Rocket Society, 50 Church Street, New York City.

NOTES AND NEWS

WITH THIS ISSUE, **Astronautics** returns to printed form and regular schedule, and it is a good issue, we think, for many other reasons besides. It reports the results of an active summer of experiment, in which the Society's engineers are moving ahead into the second phase of rocket research: that of studying aerodynamic stability. The problems of liquid-fuel motors are by no means solved, but motors of sufficient durability and efficiency are now available, as a result of the last three or four years proving stand tests, to make real high-altitude shots practical. The next step is to determine the best possible shape for rockets, from an aerodynamic point of view. This is the field in which dry-fuel shots are now producing such important data. As Mr. Africano points out at the end of his excellent technical report, dry-fuel tests offer an experimental field that any member can enter. Those interested will get many valuable suggestions from Mr. Healy's article on "Model Rockets," also in this issue.

IN A RECENT SPEECH, Adolph Hitler, Chancellor of Germany, remarked that if the war continued four or five years, Germany would have access to a weapon now under development "that will not be available to other nations." Rocket experimenters naturally wonder whether this isn't an allusion to military rockets. Prior to Hitler's rise to power in Germany, that country was among the world leaders in rocket development, and the German rocket society, the **Verein fur Raumschiffahrt,** at one time had more than 1,000 members. About 1934, the **Verein** was broken up,

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NEW STABILITY TESTS

(Continued From Cover Page)

and the altitude sighting instruments, also constructed four of the models, designated Nos. 16 to 19 . Mr. Moskowitz constructed model No. 20. Mr. Healy constructed models Nos. 6 to 11 and 21 to 27, and used the performance of model No. 5, a standard commercial ship signaling rocket of the "2-lb." type, as the basis of comparison for the altered designs of some of his other models. Model No. 27 was a two-step rocket designed to test the additional altitude obtainable from a given cartridge if it has a substantial velocity at the start instead of no velocity, as in taking off from the ground. The writer constructed models Nos. 12 to 15, intending Nos. 13 and 14, (which were built exactly alike except for added lead weights on No. 13) to show how weight alone affected the resulting altitude and performance.

Procedure of Tests

The sequence of operations was somewhat similar to that of previous tests, the models first being tied to a small carriage which runs up a track on the outstanding edge of the tee-shaped launching rack. A sharp blade fixed to the top of the rack cut the strings as the rocket shot by. Ignition was effected manually by lighting the ordinary black powder-coated fuse which comes with pyrotechnic rockets. This burns at a rate of approximately ¾ inch per second and was found to give enough time for the igniter, Mr. Goodman, to retire to a safe distance Watching the fuse intently, the catapult operator, Mr. Pierce, then pulled a cord the instant the first white flash of flame shot from the cartridge nozzle. Naturally, this required fine timing, but in almost every case it was successfully done. However, the exact effect of the catapult on the initial acceleration of

Zoltan S. Farkas
Fastening Model to Launching Rack

the rockets was doubtful. In tests with dummy models of various weights most of the energy in the rubber strands seemed to have been used in lifting the four pound carriage since the models were projected only a few feet above the top of the rack. The joint opinion of the committee was that the catapult was useful only in lifting the dead weight of the carriage, and for insuring a straight start of the flight in line with the launching rack. Improvements in the catapult will be made before the next series of tests to permit accurate calculation of the amount of initial velocity imparted by this method.

Altitude Sighting Instruments

While Pierce, Shesta and Goodman were erecting the launching rack, R.

TABLE 1. SUMMARIZED RESULTS OF 23 ROCKET SHOTS

Model No.	Max. Altitude, Feet	Time of Flight, Seconds	Total Weight of Model, Ounces	"Cartridge" size, (Nominal) "Lb."	Body Length, Inches	Max. Body Diameter, Inches	Distance, Nose to Center of Gravity,	Distance, Nose to Center of Area.	No. of Fins	REMARKS
5	403	5 (up)	11.2	2	12	1½			1 stick	Lost in clouds.
6			5.6	2	12	1¾	7⅝	11⅛	4	Exploded above rack.*
7	25	13	6.0	2	12	1½ (sq.)	7¾	10½	4	Horizontal flight—400 feet.
8	550		6.0	2	11⅜	1½	7½	9¾	4	Was expected to go higher.
9	56		9.0	2	14¾	1¼	9⅝	11½	4	Exploded above rack.
10	36	2½	11.2	4	15	2 (sq.)	9½	10½	4	Looped.
11	150	6	10.7	4	13¾	2	7⅞	9¼	4	Horizontal, then looped.
12	620	12	18.7	4	17⅞	1⅞	12⅛	15½	2 sticks	Cap ejected at top.
13	235	8	25.0	4	28⅛	1¾	18⅛	19⅛	4	Weighted model.
14			20.5	4	28⅛	1¾	18⅝	19⅛	4	Caught in rack.
15	196	9	24.0	4	17	1⅞	15⅞	17¾	2	Excessive frontal area (9 sq. in.)
16	503	6 (up)	16.0	4	18¼	1⅞	12		3	Lost in clouds.
17	725	19	34.0	6	23⅝	2⅜	16¼	16	4	Add altitude of Model 5 to this to compare with Model 27.
18	524	10	22.0	4	12½	4	8½		3	Over Observer B's zenith.
19	206	7							4	Exploded in flight.
20	75	6	37.0	6	30½	4 (sq.)	22		4	Excessive frontal area (16 sq. in.)
21	174	8½	14.0	4	16	1⅞	10½	14¾	4	Fins blew off in flight.
22	145	10	12.0	4	13½	1⅞	8¼	11½	3	Horizontal flight.
23	531	7 (up)	12.5	4	13¼	1⅞	8⅛	11½	3	Swung into the wind.
24	125	6	17.0	4	14⅞	2⅞ × 2½	8½	9½	3	Launched late.
25	582	15	14.0	4	26¾	1⅞	18¾	16¼	4	Fin area concentrated near tail.
26	66	4	13.5	4	12⅝	1⅞	7⅞		4	Looped 6 times (Acc't of front fins).
27	1930	24	39.0	6 + 2	25¼	2⅜	18½	21½	8	Shows efficiency of two-step principle.
27	2nd step alone		9.0	2	12¾	2⅜	7¾	8	4	

*Models 6 to 11, and 21 to 27 were lightened by removing part of the casing of the "cartridge." This is not recommended as exploding is apt to result.

Healy and the writer measured the distance between two points of observation selected for the location of the new altitude sighting instruments. This base line was about 1100 feet long on a straight line 50 feet west of the launching rack. Station A was 800 feet to the South, and Station B, 300 feet to the North, approximately. The formula used for calculating the altitude is similar to that used in military range-finders requiring only the angles of elevation of the **planes** of sight and the horizontal distance between the two observing stations. The formula is:

$$\mathbf{H} = \frac{\mathbf{b}}{\cot \mathbf{A} + \cot \mathbf{B}} \qquad (1)$$

Where **H** is the altitude in feet, **b** is the measure base line between stations, in feet, **cot A** is the cotangent of the angle observed from Station A, and **cot B** is the cotangent of the angle observed from Station B.

The observers were Shesta, Healy, and the writer, alternating at Station A, and Pendray at Station B. When the rocket, seen through the eye piece and cross hairs, was observed to reach its maximum altitude, a small indicator carried along in one direction by the upward motion remained in place at this point and the angle could then be read leisurely on a graduated quadrant and noted. This method gives the altitude of a horizontal line formed by the intersection of two planes rotating about shafts set parallel to each other. While it does not locate the point definitely in space, as in the method used on Staten Island in 1934, where 2 vertical and 2 horizontal angles were measured, it is sufficient for present purposes. The instruments worked well. More members should have been present to operate these instruments as here is one way in which they could have been very useful in the tests. In future tests an automatic angle and time recorder added to the present equipment will enable us to make calculations of the vertical acceleration and velocity as well as the altitude. However, in this second series of model tests, the most important thing accomplished was that the maximum altitudes reached by the models were calculated from actual observations, and not roughly estimated as in the first series. The altitudes calculated from the observed angles by Equation (1) are shown in Table I with other summarized results.

Timing the Shots

Timing of the flights was difficult owing to the low ceiling and the hilly surroundings. Models 16 and 5 both disappeared into the mist and the times for these flights were recorded only for the visible portion of the flight.* The flight of Model 18 was visible for the entire trajectory and the time given is for the ascent to the maximum altitude. The remaining times given in the table are for the entire flight, from launching rack to landing. Mrs. Pendray (Lee Gregory) acted as timer.

Weight of Powder in Cartridges

Only approximate values are known for the weight of the lifting charges and their reactions for the various sizes of commercial rockets. This will be made the subject of a special series of proving stand tests at some future date. From a study made by the writer on "6-lb." rockets, the reaction increased from zero to about 40 lbs. along a smooth parabola-shaped curve in about 1 second. The form of the reaction curve will probably prove to be similar for the different sizes and we hope by these tests to establish an empirical

formula for use in predicting the altitude and performance of the light models as used in present tests. The weight of powder for the "6-lb." size is approximately 12 oz. For the "4-lb." rocket cartridge, the maximum reaction is about 20 lbs., and the duration of the entire reaction is also approximately 1 second. The weight of black powder in this size was found by the writer to be 4.8 oz. No reaction data is available for the "2-lb." cartridge, but Mr. Healy reports the weight of powder as 2 oz.

Effect of Tail Area

This important feature of rocket design will have to await more flight data before definite conclusions can be formed. While for such objects as arrows and aerial bombs, the center of area must definitely be placed back of the center of gravity, such dogmatic assertions cannot be made for the powered part of the flight of a rocket. Of course, after the initial propulsion ceases, the rocket becomes purely a projectile, and since possibly 80% of its flight is a projectile trajectory, perhaps the known principle for this case should govern the design. Model No. 26 was specially fitted with front fins to test this point. It looped about 6 times before it landed, showing this extreme condition to be very unstable, as expected. However, for several models where the center of area was practically at or ahead of the center of gravity, good flights were made, also showing that other effects may have been acting to stabilize the rocket. Two or three designs will be selected for special study in the next set of these tests, with several similar models built to obtain data on the single factor to be investigated.

It should be remembered that present type commercial powder rockets are made and have been made for the past thousand years by rule of thumb methods and that the information we are obtaining by these tests cannot be obtained by theory or asking it of the dealer who sells us the rockets. Therefore, it is of the utmost importance that the tests be continued to increase our knowledge of how rockets behave under various flight conditions. Many devices such as parachute releasing mechanisms, timing devices, and stabilizing arrangements can be tested by means of small powder driven rockets. Model No. 12 contained a small parachute which was too tightly rolled to open, although the cap release mechanism was observed to work successfully at the top of the flight. Visible timers such as puffs of white smoke emitted at one-second intervals would be useful for observing future flights. A steady black smoke would do much to help locate the rocket against a bright sky. The smoke pots attached to models 13, 14, and 15 were an attempt to furnish this black trail, but did not prove very effective. Many of these points cannot be described in this short report but must be observed in the field to be fully understood. Building and testing small rocket models is one way in which members can help who wish to participate in our tests. Further discussion by members of the results shown in Table I will be welcomed at any regular meeting of the Society. **—Alfred Africano**

(for the Experimental Committee)

***The order of the shots, for the benefit of those wishing to identify their numbered photographs, was as follows: Models 16, 5, 6, 23, 18, 12, 19, 13, 14, 17, 15, 20, 8, 25, 9, 10, 22, 24, 21, 11, 27, 26, and 7.**

PHOTOS APPEARING IN ASTRONAUTICS may be obtained in 5" by 7" size. Price to members $1, to non-members $1.25.

Thermal Efficiency Overemphasis

A More Practical Yardstick of Rocket Motor Performance Is Suggested By John Shesta

WHEN the American Rocket Society first began experimenting with rocket motors in a proving stand, thermal efficiency was adopted as a criterion of motor performance. In making this choice we followed the precedent set up by general engineering practice of rating heat engines on the basis of thermal efficiency. Another reason, perhaps, was our rudimentary knowledge of rocket principles at the time.

This somewhat unfortunate choice of criterion is responsible for a great deal of confusion, and a general tendency to exaggerate the importance of the role played by thermal efficiency in the performance of rocket motors. Actually the thermal efficiency of a rocket motor is of academic interest only. It does not provide a measure of the possible altitude of a rocket propelled by such a motor, and it gives misleading results by obscuring the real issues involved.

What does the thermal efficiency signify? As applied to a rocket motor it is that fraction of the theoretically available fuel heat which is converted into kinetic energy of the jet. Ideally this conversion should be complete, but actually it never is, because (1) The high combustion temperature causes the phenomenon of dissociation, (which means that for all practical purposes some of the fuel remains unburned) and thus a fraction of the available heat is never realized; (2) Some of the heat that is realized is lost in the hot exhaust gas; and (3) The gas friction in the nozzle introduces another loss in the so-called "nozzle reheat." In general these losses will increase with our working temperature, but this is the price we must be prepared to pay for the use of such highly concentrated energetic fuels as we employ in liquid fuel rockets.

It is true that thermal efficiency is of importance in industrial applications of heat engines, because it shows us how economically the fuel, which costs money, is being used. The air necessary for the combustion is free, so it is not considered.

A rocket, however, uses not air but expensive liquid oxygen, and what is still more important, this oxygen as well as the fuel and any inert ingredients we may choose to add, all represent weight that the rocket must lift. Thermal efficiency merely tells us how well the **heat** of the fuel is being utilized, whereas what we want to know is how effectively the **weight** of the propellant is made use of. After all, in a rocket we are mainly interested in results. Reaching a high end velocity or altitude is the prime desideratum, regardless of how efficiently it is done.

The one rational basis of comparison for rocket motors is provided by the jet velocity attained, since it gives an absolute measure of results. The formula for reaction is:

$$R = \frac{vw}{32}$$

(jet velocity times the weight of exhaust per second, divided by G). Now since the weight of the exhaust is the same as the weight of propellant before burning, the jet velocity shows exactly how much thrust is generated by a given weight flow of propellant.

	RUN I	RUN II
Chamber Pressure	147 #/in.	147 #/in.
Carbon Feed	.375 #/sec.	.273 #/sec.
Liq. ox. feed	.625 #/sec.	.727 #/sec.
a	4	1
t (reaction coeff.)	.45	.25
Products	CO_2 .155 #	CO_2 .250 #
of	CO .776 #	CO .477 #
Combustion	O_2 .069 #	O_2 .273 #
Comb. temp. F° Abs.	6800	6620
Theoretical **JET VELOCITY**	**9440 ft/sec.**	**9020 ft./sec.**
K. E. of Jet	1392000 ft#/sec.	1270000 ft#/sec.
Heat Energy input	4250000 ft#/sec.	3090000 ft#/sec.
THERMAL EFFICIENCY	**33%**	**41%**

Just how important the jet velocity really is can be shown by the following example. Consider two hypothetical rockets A and B, identical in all respects except one, namely, rocket A has twice the jet velocity of rocket B due to great difference in the completeness of combustion. With the same reaction, then, A will use $\frac{1}{2}$ the amount of propellant needed by B and consequently will go four times as high as B.

Now it may be argued that jet velocity and thermal efficiency are related to each other, and that a high jet velocity necessarily presupposes a high thermal efficiency. This is not the case. We can actually get a high jet velocity with a low thermal efficiency and vice versa. In order to illustrate this possiblity, let us assume two test stand runs made with a certain rocket motor under the same conditions, but with different proportions of fuel to oxygen. To simplify calculations we shall use pure carbon as fuel, rather than the more complex fuels such as alcohol, gasoline, etc. The combustion reaction has been computed in accordance with the equation:

$$2a\,C + (1+a)\,O_2 \longrightarrow 2t\,CO_2 + 2\,(a-t)\,CO + (1-t)\,O_2$$

For a complete discussion of the combustion phenomena the reader is referred to **"L'ASTRONAUTIQUE"** by R. Esnault-Pelterie, whose method and data have been used in calculating the table given above.

It will be seen from this table that while Run I gives higher jet velocity its thermal efficiency is lower than that of Run II. The figures certainly raise the question whether the old method of computing rocket motor results, on the basis of thermal efficiency, ought not to be abandoned, and the method of jet velocity adopted.

Instead of the jet velocity, however, we could adopt a more convenient unit as a figure of merit for rocket motor performance. We can use the "Thrust Coefficient", which is equal to the jet velocity divided by G, or 32. This figure is very useful and convenient as it enters into all rocket calculations directly, giving as it does the thrust developed by using one pound of propellant per second. In case of a test stand run the thrust coefficient is calculated simply by dividing the thrust developed, into the combined weight of fuel and oxygen per second.

British Fly Rocket Plane

Use Air Jet Similar To Campini Patent.

Since the 1928 flight of Fred. Sthamer, in a glider propelled by powder rockets, numerous similar short, pointless flights have been reported. First news of serious experimental work with an airplane powered by a jet motor appeared in the Aviation Section of the New York Times for Sunday, July 30, 1939.

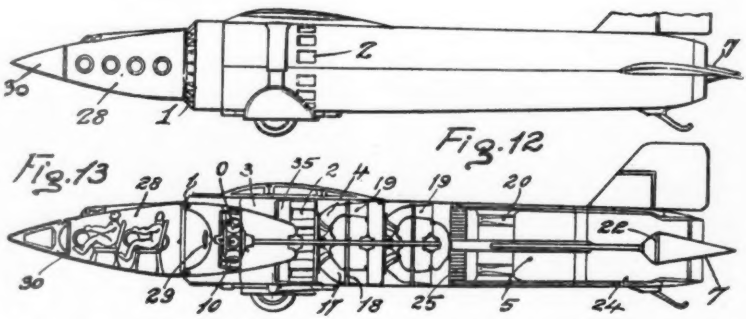
The article describes in detail the successful flight of an air jet propelled plane invented by Mr. Frank Whittle, an ex-member of the Royal Air Force. The device operates as follows, quoting from the news item:

"The invention consists primarily of a centrifugal compressor, a turbine, a combustion chamber with propelling nozzles through which the gas is discharged to propel the plane. The unit is arranged so that the compressor continuously draws large quantities of air from the atmosphere through an opening in the front of the plane, and, compressing it, passes it to a combustion chamber, through which it flows continuously, receiving heat as it does so from the combustion of oil fuel, the heating thus taking place at constant pressure.

"From the combustion chamber the air passes through nozzles to the buckets of a turbine, which is coupled to the shaft of the compressor. The expansion through the turbine is only sufficient to enable it to drive the compressor, and a second expansion takes place through a nozzle situated in the after portion of the plane. The heating of the air in the combustion chamber increases the velocity of the air tremendously and it is the backward thrust of this airflow which provides the propulsion force for the plane."

A United States patent, number 2024274, issued in 1932 to Mr. Secundo Campini of Milan, Italy, covers a very

(Continued on Page 14)



Drawing taken from U. S. Patent 2024274 issued to S. Campini, showing his reaction propulsion method and plant.

LETTERS TO THE EDITOR

WHY SHOOT DRY FUEL ROCKETS is a question several members of the society have been asking. I. Pasternak, of Bronxville, N. Y., writes as follows:

"Past issues of **Astronautics** have clearly defined the Society's position regarding dry fuels. Why has the Society changed its attitude in this important matter? Has some discovery been made regarding an inherent weakness in the use of liquid fuels or has a small group of dry fuel advocates in the organization been spreading a litle propaganda?

"If aerial stability and landing methods re to be investigated, why not use liquid fuel models?

"You would not try to learn to swim by using an improper stroke and change over to the correct stroke later. It's much better to learn the right way first even if it takes longer.

"I would certainly like to hear the comments of a few of those members who still believe liquid fuels will be the final solution to commercial rocket flight."

We believe Mr. Pasternak can be assured that recent dry fuel tests are not the result of "dry-fuel propaganda", and we are equally certain that the Society has not abandoned liquid fuels. The reasons for the dry-fuel tests on stability and aerodynamic form are clearly set forth, we believe, in Mr. Roy Healy's article on "Model Rockets" on Page 11 of this issue. In any case, the Editors of **Astronautics**, with Mr. Pasternak, would like to hear the comments of liquid-fuel fans.

WHAT WAR MEANS to rocketors is rather dramatically revealed in recent correspondence with British experimenters. For example, this letter from Arthur C. Clarke, Treasurer of the British Interplanetary Society, to Mr. Africano:

"Owing to the War, it will be impossible for the B. I. S. to carry on an active existence, and arrangements have been made to put it in cold storage for the duration.

"In order that our work will not be entirely lost, whatever happens to us, I am sending you a few copies of our last two "Journals". These contain merely the general outlines of the theoretical work we have done, but they may assist others to follow up the same lines of research . . .

"After the War any surviving members of the Council will attempt to start things going again, but until then—whenever that may be—it's no good making any plans for the future. I myself shall probably be moved from London to parts unknown in the course of the next few days, and if you wish to communicate with me again it would be best if you wrote me care of "Ballifants". Bishops Lydeard, Taunton, Somerset, (England). Letters to this address (which is safely buried in the heart of the country) will probably reach me eventually.

"If the worst comes to the worst—which I don't for a moment think it will—we hope that the ARS will be able to see that our work has not been entirely wasted. If it doesn't, I hope to be able to get into touch with you again and perhaps under more propitious circumstances we may at last be able to get this exchange of publications between the two Societies going more smoothly."

The numbers of the Journal of the British Interplanetary Society which Mr. Clarke sent were those of January and July, 1939, outlining, as many ARS members recall with interest, plans for an interplanetary rocket which resulted from an elaborate and painstaking study made by committees of the BIS.

STREAMLINES MADE VISIBLE: Members who attended a recent meeting of the American Institute reported that the demonstration, "Wonders of Flight", given by staff members of the Franklin Institute of Philadelphia, utilized a simple method of making streamlines visible for study. A piece of "dry ice" in a bottle of water provided a steady stream of cold carbon dioxide gas made visible presumably by the droplets of water it carried. A blower fan and nozzle then directed this fine mist-like stream over airfoils, automobiles and other objects.

The Rocketor's Workshop

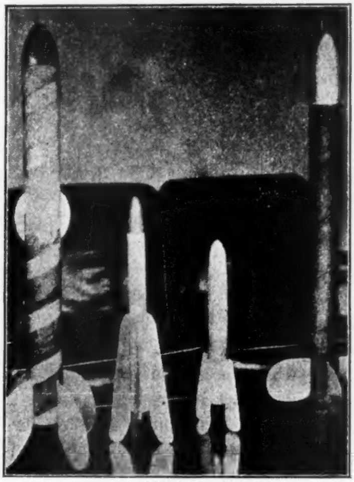
A Department Devoted to Shop-Talk, Ideas, Devices

MODEL ROCKETS—Mr. Healy Tells How to Build Them

Despite the fact that the liquid fuel rocket is the logical choice for aerological research, the dry fuel or powder rocket still retains a sphere of usefulness. Because of its cheapness and simplicity it is an excellent means of testing various shaped hulls for performance under rocket power, determining stability of design, for solving fin problems, testing locations of center of gravity in relation to other centers and invaluable in training members in launching rack technique, timing, photography and the innumerable details incident to a well executed rocket shot. Much can be learned from these powder rocket shots, yet it is wise to keep in mind the dissimilarities between liquid and dry fuel rockets to prevent drawing hasty and erroneous conclusions.

Motive power for the Mountainville flights was supplied by charges of three sizes, the "2 lb." type obtained by the writer, "4 lb." size charges remaining from the Pawling experiments[1] and a few "6 lb." left over from the Van Dresser-Africano tests at Danbury[2]. The keeping qualities of powder charges were proved by the undiminished thrust of these aged 4 and 6 lb. cartridges.

The initial step in converting these charges into model propelling units was the precaution of removing the fuse and plugging up the nozzle with a wad of paper. Next the head or garniture, containing the bursting charge, was removed. The stick holder and outer wrapping of colored paper were then peeled off. In an attempt to reduce the weight of the models to a minimum some of the charges were stripped of several of the many layers of cardboard surrounding the compressed powder. The advisability of doing this has not been fully determined, for while three of the models, evidently overstripped, exploded in mid-air, both charges of the successful setp-rocket were so prepared, as were those of several other well-performing models. Next and final step was the sealing of the upper ends of the charges with discs of cardboard and strong glue, a process requiring care, for two flights were spoiled by charges firing through the top as well as out the nozzle.



HECHT Photo

Models 27, 9, 8 and 25

[1]Rocket Tests At Pawling. "ASTRONAUTICS" No. 38 Oct. 1937
[2]Dry Fuel Experiences—Van Dresser "ASTRONAUTICS" No. 41 July 1938

HECHT Photo

Roy Healy explains his two-step rocket to President Africano

(3) **Solid balsa wood.** Two blocks of balsa were half-hollowed to snugly accommodate a charge, leaving sufficient solid wood above the hollows from which to construct the head of the model. The halves were glued together under slight pressure and afterward whittled and sandpapered down to the desired form. It was found necessary to back the sandpaper with cardboard to prevent following the soft spots in the wood, which tendency creates an uneven appearance. Reducing to plan can be accomplished more easily where a lathe is used to rotate the block, a sheet of sandpaper being held against the spinning wood.

Hulls for the models were prepared with the following materials:

(1) **Cardboard mailing tubes** of various lengths and diameters. While not streamlined according to current standards, these are easily obtainable and served admirably for simple models. Where necessary the charges were shimmed out to fit the tubing, the botton of the charge in all cases being flush with the end of the hull. (As the thrust line of the rocket must lie at all times along its longitudinal axis any movement of that axis will produce a corresponding movement of the thrust line, hence there is absolutely no difference in the relative stability of a rocket if the center of propulsion is located above, on or below the center of gravity.) Charges were secured in position within the tubing by metal fin screws or by a balsa block tacked in place above the charge.

(2) **Thin dural tubing.** One of the sleekest models was constructed by slipping a charge into a length of dural tubing, and securing it by the fin attachment screws. Unfortunately the charge in this model burnt out thru the top.

(4) **Built-up balsa.** By using laminated former rings around a "6 lb." charge, connecting by stringer strips and covering this frame with thin sheet balsa a model of accepted streamline form was obtained. Fitted with balsa fins and doped to a glossy finish this model promised excellent performance, but alas! its top blew off on the way up.

(5) **Sheet dural.** The fantastic Plutonian Special #20 and the Red Martian Express #18 were built up of riveted sheets of dural, with hollowed fins of similar construction. The latter made a creditable flight, the former lobbed thru the air like a beer bottle out of the bleachers.

Heads for the models in which they were not integral were turned from balsa blocks, in some cases on a lathe, in others by cupping a cone of sandpaper in the palm of the hand

and rotating the balsa. Naturally the lathe does a more symmetrical job, but passable heads of any ogive from a cone to a half hemisphere can be formed by the hand method after a little practice. A stepped-down portion was cut at the bottom to fit within the tubing hull for securing the head, extra wood being left for sanding down to a smooth joining to the hull.

Fins of various sizes and shapes were constructed of:

(1) Thin dural sheet metal—with a right angle flange in which holes were drilled for attachment to hulls by means of screws.

(2) Balsa sheet—glued to balsa or cardboard bodies. Fins of this type must be attached securely in such a position that they will not be burned by the jet flame. They should be gently handled until shot. Study of the Mountainville tests seem to indicate that the use of four fins, fairly large in comparison to the hull size, give best stability.

After a few seconds of flight the coloring of the rocket becomes indistinguishable, but for appearance's sake and to assist in retrieving the models most of them were daubed with distinctive colors. Cardboard tubing and balsa will take water colors, several coats being necessary for brightness. Metal hulls and fins can be given a high polish by rubbing with steel wool and oil, or many be painted. Several coats of dope applied over a wood filler, sanded between coats, will give a glossy finish to balsa hulls and heads.

The powder rockets described here were of quite simple construction, purposely so, and will serve as a basis for more elaborate models containing landing and recording devices.

—**Roy Healy**

THE ROCKETOR'S LIBRARY

For the convenience of members, the Society's library now has available at cost the following items of interest to rocket experimenters and enthusiasts.

ROCKETS THROUGH SPACE, by P. E. Cleator (277 pages); a popular treatment of rockets, their history, how they work and what they promise. Price to members $2; to non-members $2.50.

LIQUID PROPELLANT ROCKET DEVELOPMENT, by Robert H. Goddard (10 pages and photographs); the official report of Dr. Goddard's research up to the year 1936. Price 25¢.

DESIGN OF A STRATOSPHERE ROCKET, by Alfred Africano; a reprint with drawings of Mr. Africano's REP-HIRSCH Prize paper. Only few left. Price 25¢.

SUPPLEMENT TO L'ASTRONAUTIQUE, by Robert Esnault-Peleterie; the famous French engineer amplifies his L'ASTRONAUTIQUE. (83 pages, tables, appendix). Price to members $2; to non-members $3.

MISCELLANEOUS DRAWINGS, useful in suggesting experimental design. Price, per set of 6, 50¢; each 10¢. Subjects: (1) Rocket No. 2/1932, (2) Cross section of motor of Rocket No. 2/1932, (3) Cross section of motor used in 1935 tests, (4) Schematic drawing of proving stand used in 1935 tests, (5) Result of motor tests, Series 3, No. 1, (6) Results of motor tests, Series 3, No. 2.

ASTRONAUTICS — Back numbers are becoming scarce. If you would like to obtain copies of the early publications of the Society, order now.

Copies of the current year 75¢; numbers 18 to 40 inclusive $1; numbers 11 to 17 inclusive $2; numbers previous to 11 $5.

Cash must accompany order. Address requests to the Secretary.

BRITISH ROCKET PLANE

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similar method of propulsion for aircraft. Campini designed narrow, slotted air intake openings completely surrounding the fuselage behind the compartment for pilot and passengers, as illustrated in his drawing. An alternative method was to move the occupant's cabin back and upward to the conventional position and use the circular nose of the plane as an air inlet.

After being scooped in, the air was to be compressed by a pump requiring a separate motor. The compressed stream was then to be forced thru a section containing heating units burning oil to further increase the air velocity and energy content before jetting out through an annular opening in the tail.

The principal difference between the two designs is that the new British ship has a turbine added in the thermal circuit on the compressor shaft and apparently the motor proposed by Campini, which was to drive his compressor, has been eliminated. If the motor has been eliminated, Mr. Whittle apparently has operated successfully a gas turbine. If so, this work is significant, for recent figures available on gas turbine operation and thermal efficiencies indicate that within the temperature limitations of nozzle and blade metals, the power developed by the turbine alone is just enough to drive the compressor.

National Advisory Committee for Aeronautics reports of investigations into rocket propulsion using compressed air and liquid fuel, have been unanimous in pointing out the exorbitant percentage of energy which must be put back into the compressor. Another disadvantage, made obvious by the Campini drawings, is the huge size of the plane in comparison to its limited carrying capacity. At least 80 per cent of its internal volume is taken up by the propelling mechanism needed to handle the large quantity of air.

Where openings are narrow and slot-like there is a large percentage of surface area exposed to the flow of intake fluid compared to the volume (cross section), which still further increases resistance. This fact, combined with unavoidable losses in the operation of Campini's and similar devices due to conduit friction and change of velocity, at least appear to make any high thermal efficiencies unlikely.

With England engaged in a war, and every new aeronautical device a closely guarded secret, it is doubtful whether more news of this research will be obtainable. At any rate the A. R. S. is endeavoring to get further technical data on the plane and will report it when available.

—James R. Glazebrook

More detail on another postal flight comes from India, where Mr. Stephen H. Smith, of Calcutta, has been sending mail and other "payloads" by rocket for several years. On April 25, at Garia, he fired two rockets, Nos. 162 and 163. The first was a large rocket airplane about six feet across. According to the "Star of India" it took off well and flew a considerable distance, when unfortunately the exhaust burned through the metal fuselage and the machine fell to the ground. The second rocket was smaller, and no details were given, except that it flew in a straight line for some distance, then turned slowly in a wide circle and returned to its starting point.

NEWS OF MEMBERS

NEW MEMBERS: At the suggestion of the Board of Directors, **Astronautics** will hereafter print from time to time the names of new members and renewal members, together with the cities in which they live. The idea is to promote acquaintance among members and stimulate more cooperation on rocket experimental projects. Complete addresses will not be given, for obvious reasons, but if any member wishes to get in touch with another, a letter sent to him in care of the Society's Secretary, at 50 Church Street, New York, will be forwarded. Thereafter, if the recipient wishes, the correspondence can be carried forward on a person-to-person basis.

Recent new and renewal members include:

Active Members:

Lawrence W. Lawson, Brooklyn, N. Y.
Parker Zell, Inglewood, Calif.

Associate Members:

George F. Muir, East Hartford, Conn.
Julius Dalma, New Orleans, La.
Dr. William M. Malisoff, New York City
John R. Menke, New York City
Robert H. Lloyde, Ingelwood, Calif.
Harris D. Dean, Lansing, Mich.
Robertson Youngquist, Boston, Mass.
Joseph T. Tasker, Georgetown, Demerara, British Guiana
William N. Hite, Stanford University, Calif.
Dr. Thomas A. Terry, Havana, Cuba
Glennon C. Unterreiner, Crystal City, Mo.
Dr. T. Nakamura, New York City
Harry A. Gould, Harrisburg, Pa.
R. J. Scaff, Commerce, Texas
John Erickson, Minneapolis, Minn.
Royal W. Barsh, Jersey City, N. J.
Gordon Taylor, London, England

Junior Members:

Scribner Fellows, New Britain, Conn.
A. Owczarak, New York City
James Gruver, Porterville, Calif.

MR. BERNARD SMITH, builder of A. R. S. Rockets No. 2 and 3 and one of the leaders in rocket research in the Society's program of experiments with liquid fuels, is continuing his experiments with rocket motors in Los Angeles, where he now lives. Mr. Smith recently visited Mr. Africano and other experimenters in New York, and left two new motors with the Experimental Committee for testing. These motors are unique in that they are partly composed of carbon, which is expected to burn with the other fuels, adding to the thrust while overcoming, Mr. Smith expects, some of the difficulties connected with cooling. Full reports will be made on these motors later.

MR. JAMES H. WYLD, designer of the concentric tubular motor which last season proved to be the most efficient yet tested by the Society, recently moved to Langley Field, Va., where he has accepted a position with the National Advisory Committee for Aeronautics.

WAR ABROAD has affected the plans of many European members of the A. R. S. Mr. Phil Cleator, one of the founders of the British Interplanetary Society and author of "Rockets Through Space", was forced to postpone a long-planned visit to the United States this autumn for that reason. As reported elsewhere in this issue, the British Interplanetary Society has been forced to suspend for the duration of hostilities.

NOTES AND NEWS

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and some of its leaders left Germany. Since then, news of rocket experiments in Germany have been vague and contradictory. Many American experimenters believed that the German work had stopped. Possibly it merely became a part of the country's general preparedness for war.

GOOD NEWS TO ROCKET BUILDERS is the announcement by Edgar R. Larsen, chief metallurgist of the Beryllium Alloys Company, of discovery of an unusually large deposit of beryl ore at Vista, Calif. Having a specific gravity of only 1.84, compared with aluminum's 2.7, this metal possesses a hardness and melting point equal to that of steel. The Society's investigations have several times called attention to the superior qualities of this metal for motors, but high cost has heretofore prevented its use. The price of beryllium has recently been cut from $22 to $11 a pound, with further reductions in prospect.

POSTAL ROCKETS: One of the most ambitious recent experiments with mail rockets is reported from Cuba where, on October 1 and 3, at the Army Target Field, a rocket was tested by the Philatelic Club of the Cuban Republic (Club Filatelico de la Rep. de Cuba). The object was to carry mail by rocket from Havana to Matanzas, a distance of about fifty miles, according to reports in the British "Airpost Journal". A newspaper report sent to **Astronautics** by the Philatelic Club called the experiment a "complete success", but does not state how far the rocket flew, what load it carried, or other details. Conducting the experiment, however, was Dr. Tomas Terry, who has recently become a member of the American Rocket Society. Dr. Terry has promised to send technical information presently.

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